Solar Water Heating for the Residential, Commercial and Industrial Sectors

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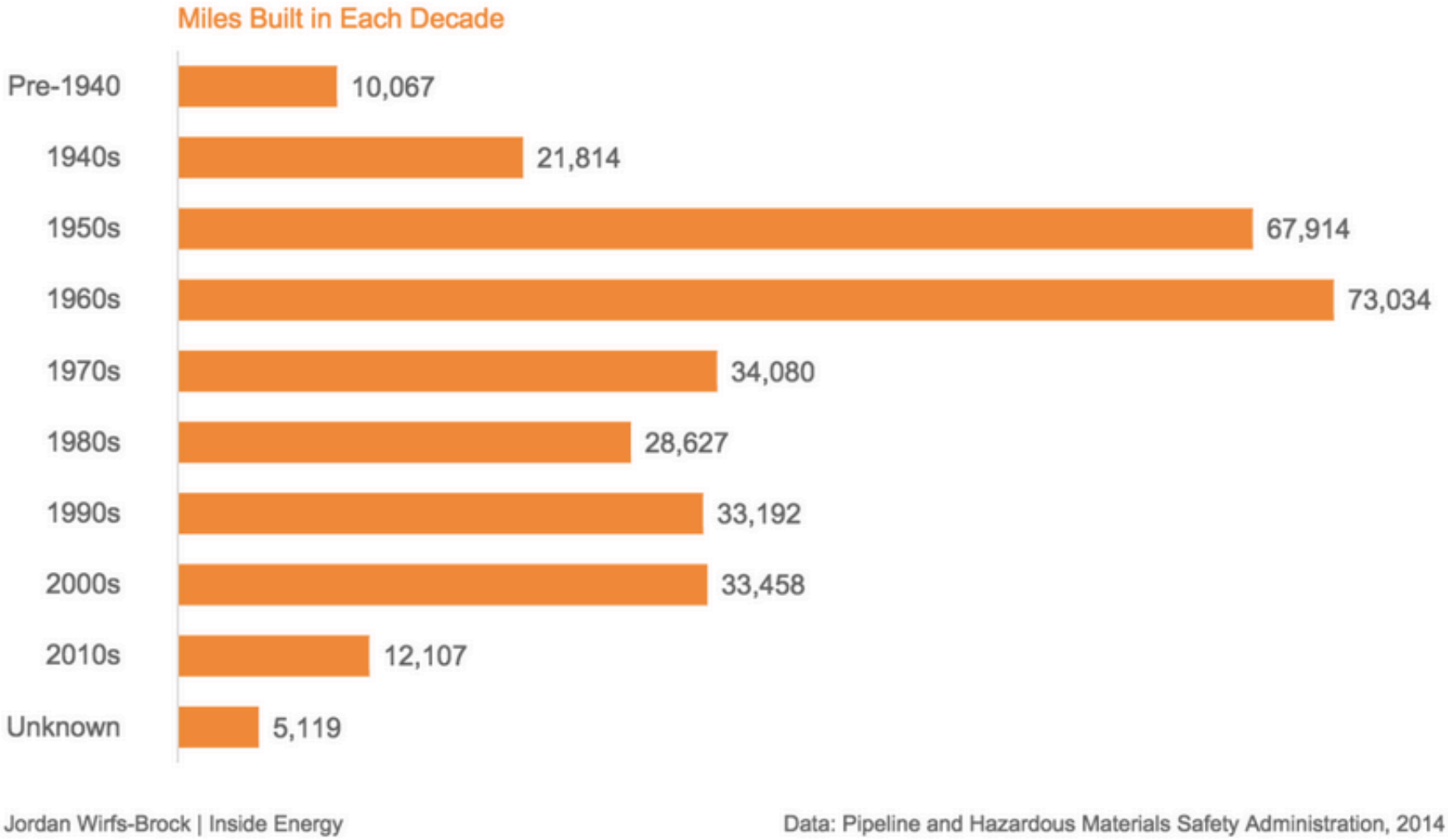
Motivation

Aging Natural Gas Infrastructure



46% of transmission pipelines were built in the 50s and 60s

Some Facts

- Water heating accounts for almost 20% of energy consumption in households in the U.S.
- Almost 50% of California's In-State Generation comes from Natural Gas

Aliso Canyon Gas Leak (2015)

Project Goals/Objectives

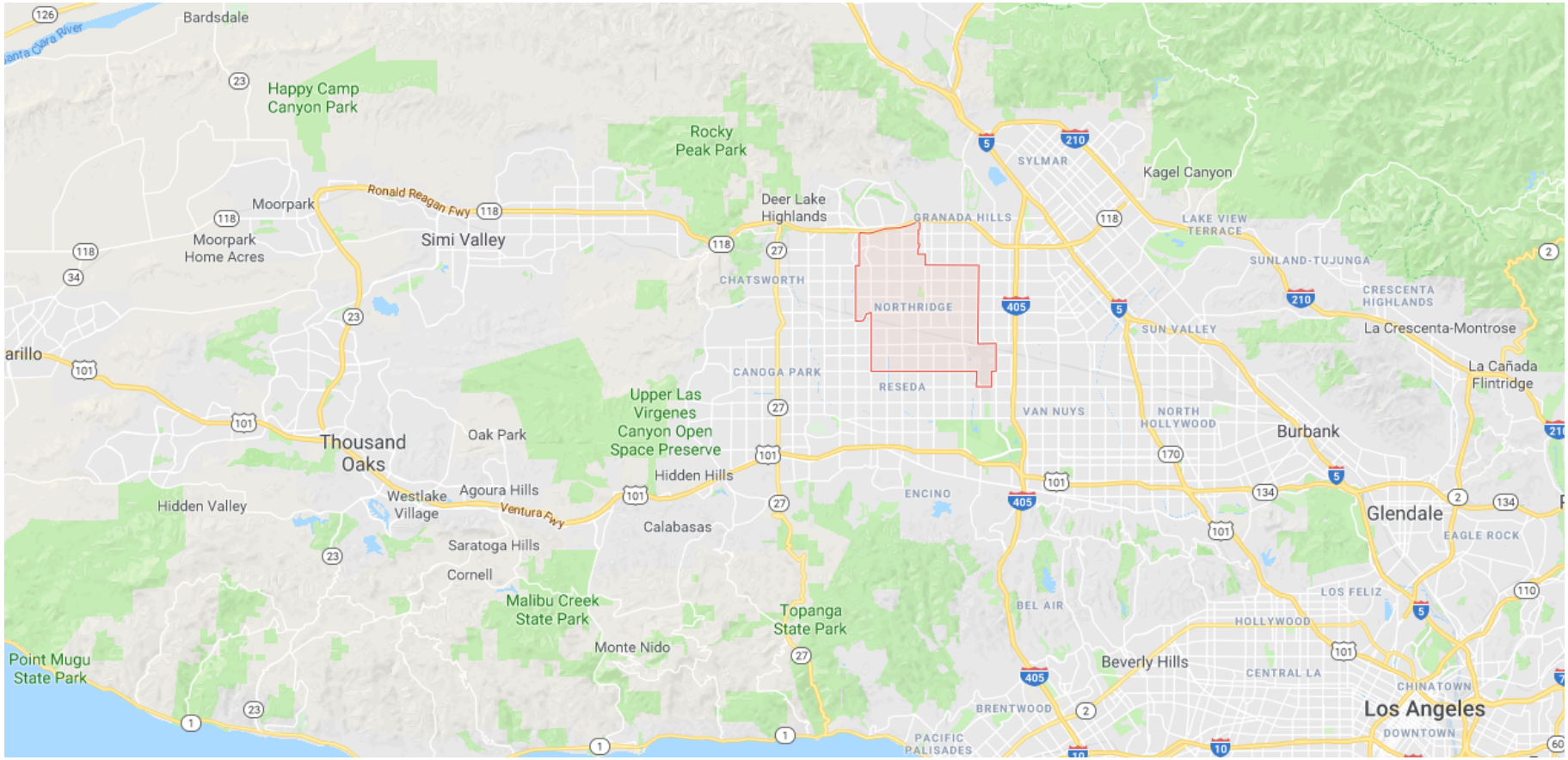
Goals:

- Demonstrate reduction in natural gas consumption for water heating
- Promote wider adoption of minichannel solar water heating technology.
- Overcome technological, economic and market challenges by identifying, targeting and demonstrating the minichannel technology

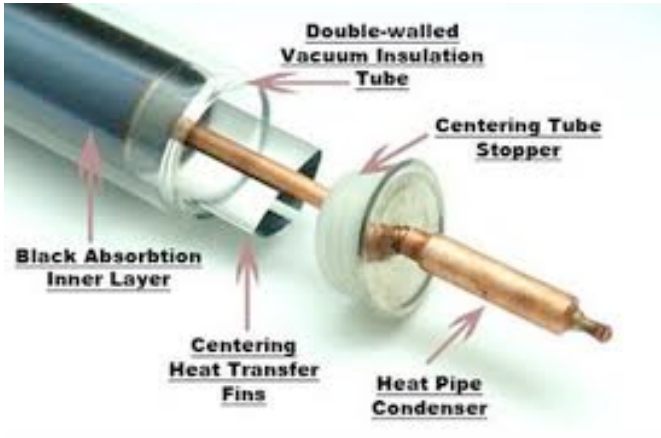
Objectives

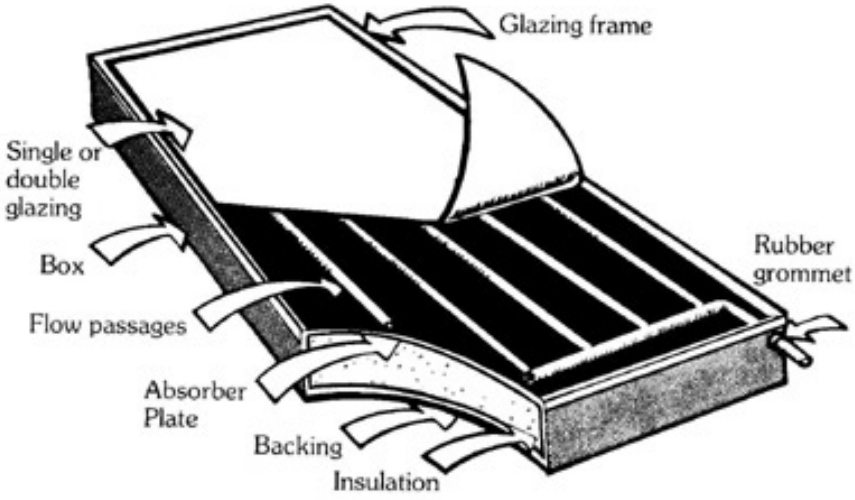
- Demonstrate reliable performance through monitoring and verification.
- Develop and demonstrate aluminum and copper minichannel solar water heating technology
- Identify key implementation challenges and possible ways to overcome them.

Location

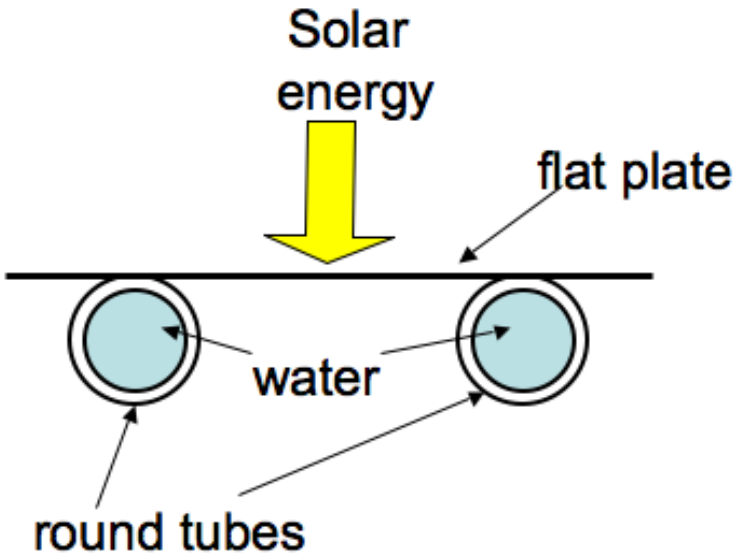

Bardsdale
Happy Camp Canyon Park
Rocky Peak Park
Moorpark
Moorpark Home Acres
Ronald Reagan Fwy
Simi Valley
Deer Lake Highlands
SYLMAR
Kagel Canyon
GRANADA HILLS
LAKE VIEW TERRACE
SUNLAND-TUJUNGA
CRESCENTA HIGHLANDS
CHATSWORTH
NORTHRIDGE
SUN VALLEY
La Crescenta-Montrose
La Cañada Flintridge
CANOGA PARK
RESEDA
VAN NUYS
NORTH HOLLYWOOD
Burbank
Upper Las Virgenes Canyon Open Space Preserve
Oak Park
Thousand Oaks
Hidden Hills
Westlake Village
Agoura Hills
Hidden Valley
Ventura Fwy
ENCINO
Glendale
EAGLE ROCK
Calabasas
Saratoga Hills
Cornell
Malibu Creek State Park
Topanga State Park
LOS FELIZ
BEL AIR
HOLLYWOOD
Monte Nido
Point Mugu State Park
Beverly Hills
CENTRAL LA
CHINATOWN
Los Angeles
DOWNTOWN
BRENTWOOD
PACIFIC PALISADES

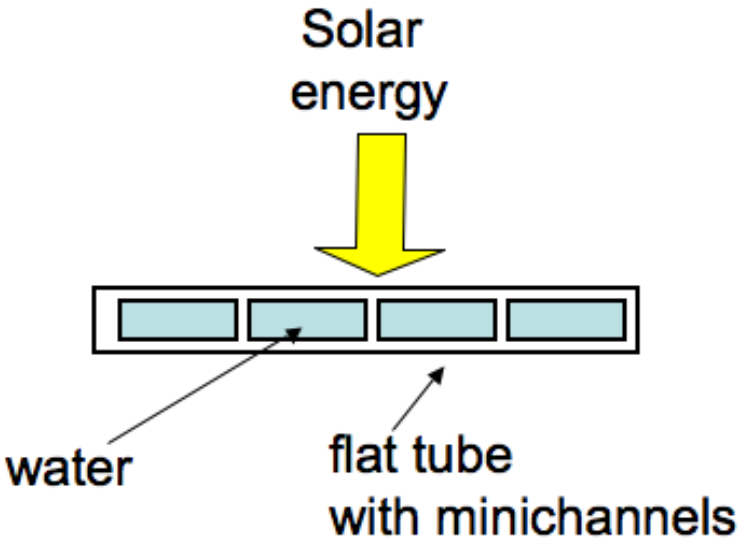
Solar Collector Configurations

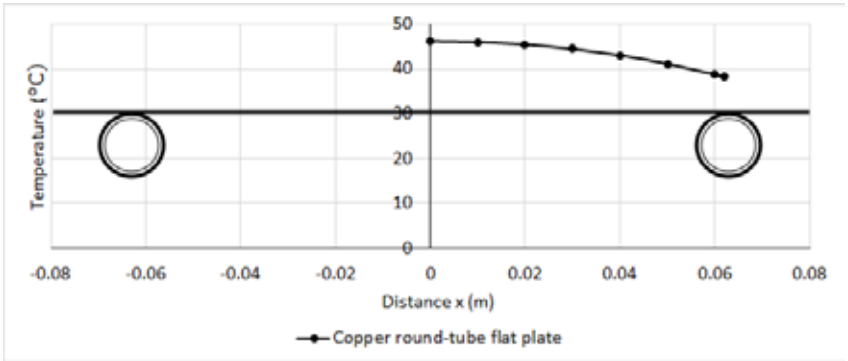


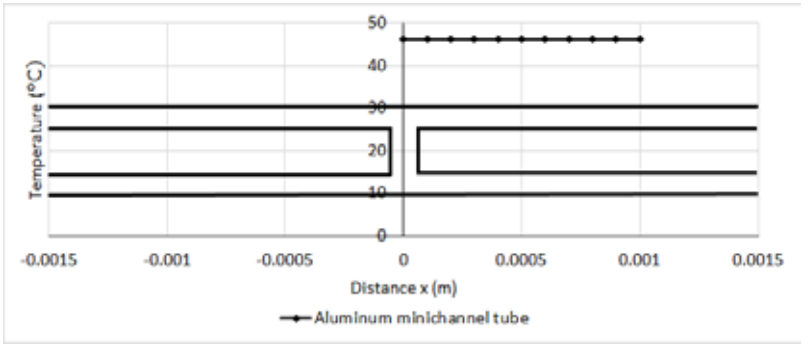


Minichannel tubes and Solar Energy

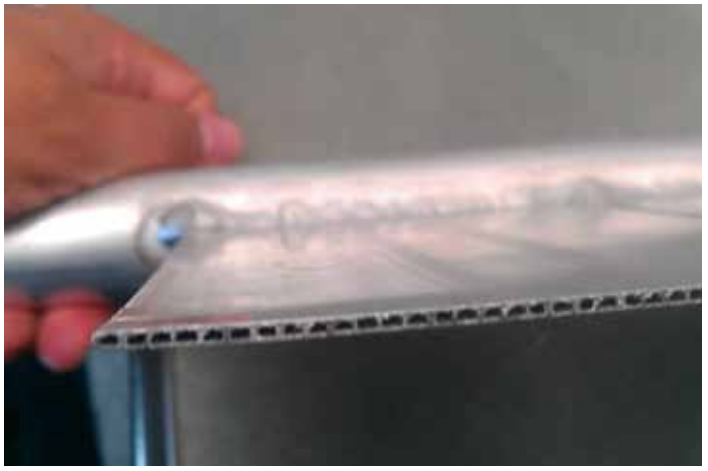






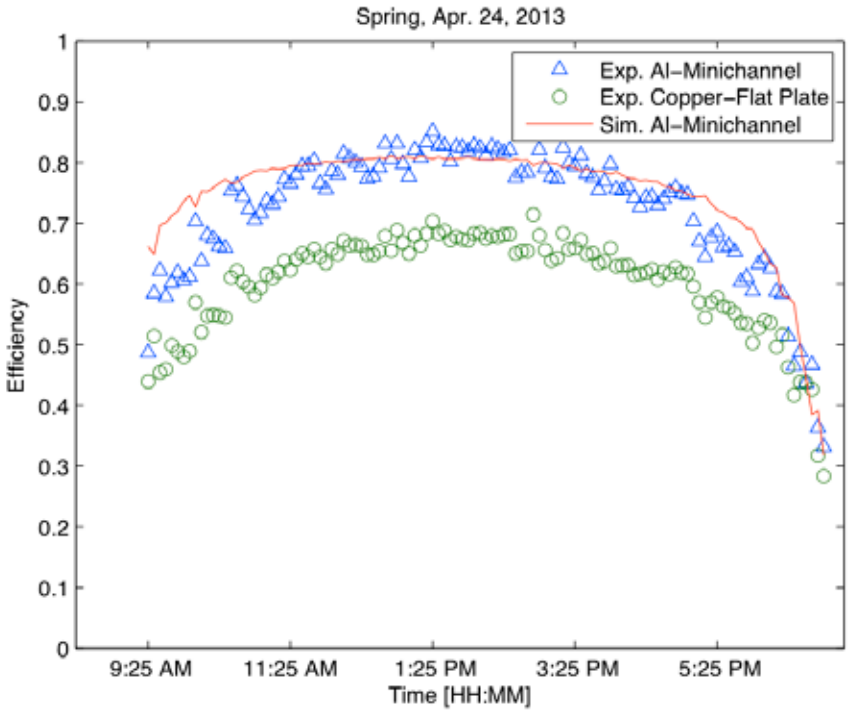


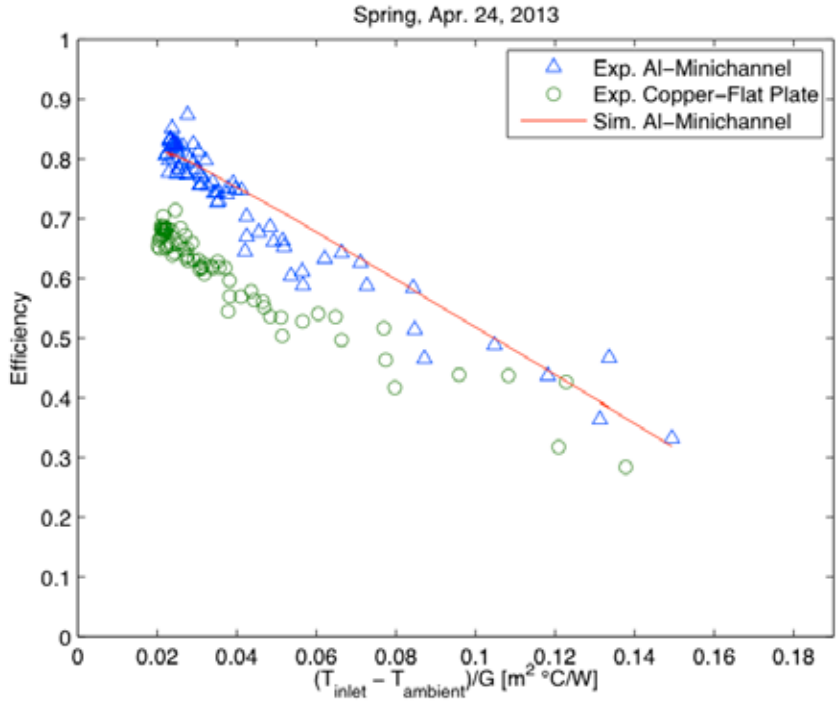
Aluminum Minichannel Collector



Selective coating: Black chrome (EC series): α=.95, ε = .12

Thermal Efficiency





Thermal Efficiency Improvement > 10%

Robles et al., Solar Energy, 110 (2014) 356-364

Prototype Collector Cost

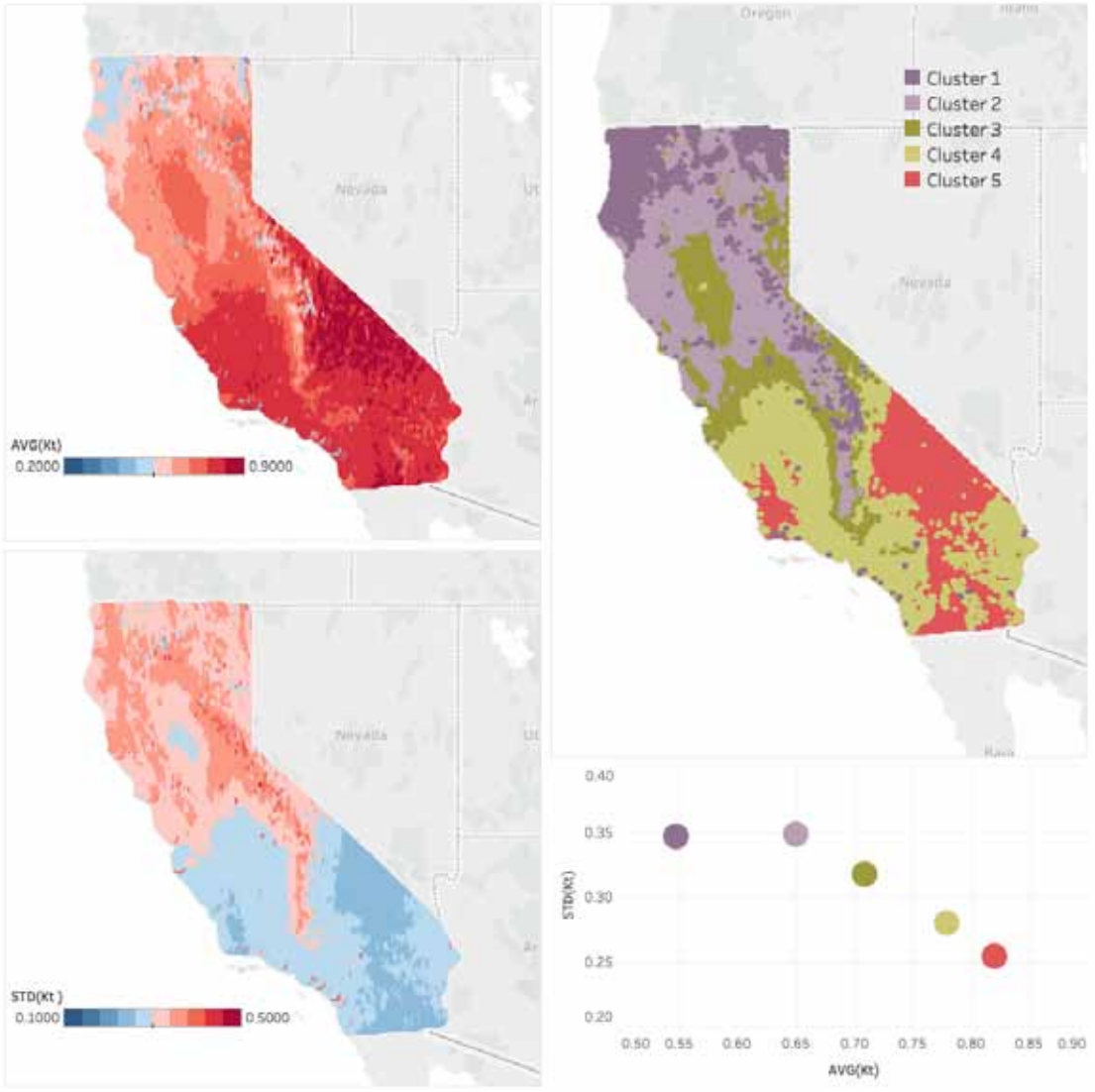
10 ft. by 4 ft. (3.7 m^2) aluminum minichannel solar collector

- Aluminum minichannel tubes = $440
- Headers = $28
- Collector frame and glass = $500
- TIG welding = $1056
- Total = $2024, or **$50.6/ft^2 (or $544.65/$m^2$)**
- Estimated cost for mass produced unit: **$14.43/$ft^2$ (or $155.32/$m^2$)**

Average conventional collector **$51.42/$ft^2$ (or $553.50/$m^2$) ***

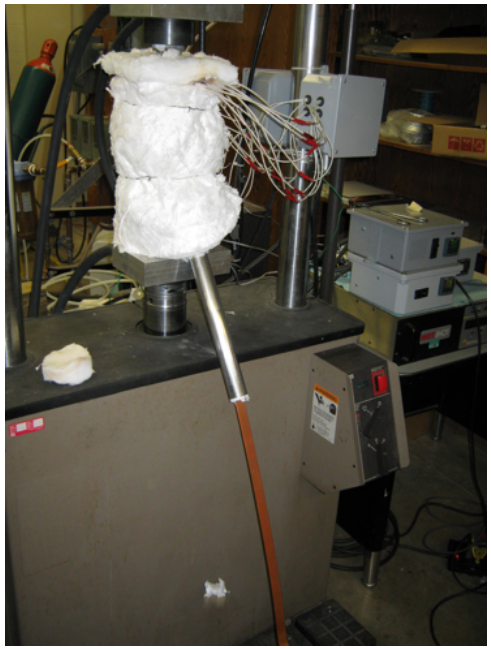
* GTM Research and SEIA, 2011

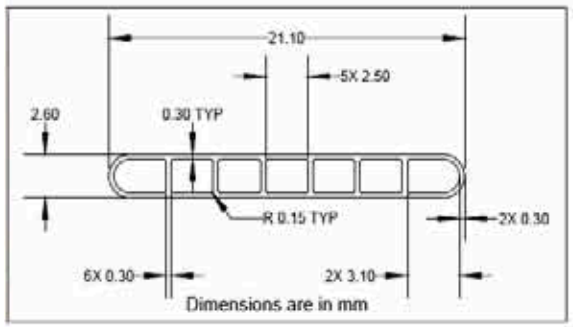
UCSD – Solar/NG Resource



Prof. Carlos Coimbra's group

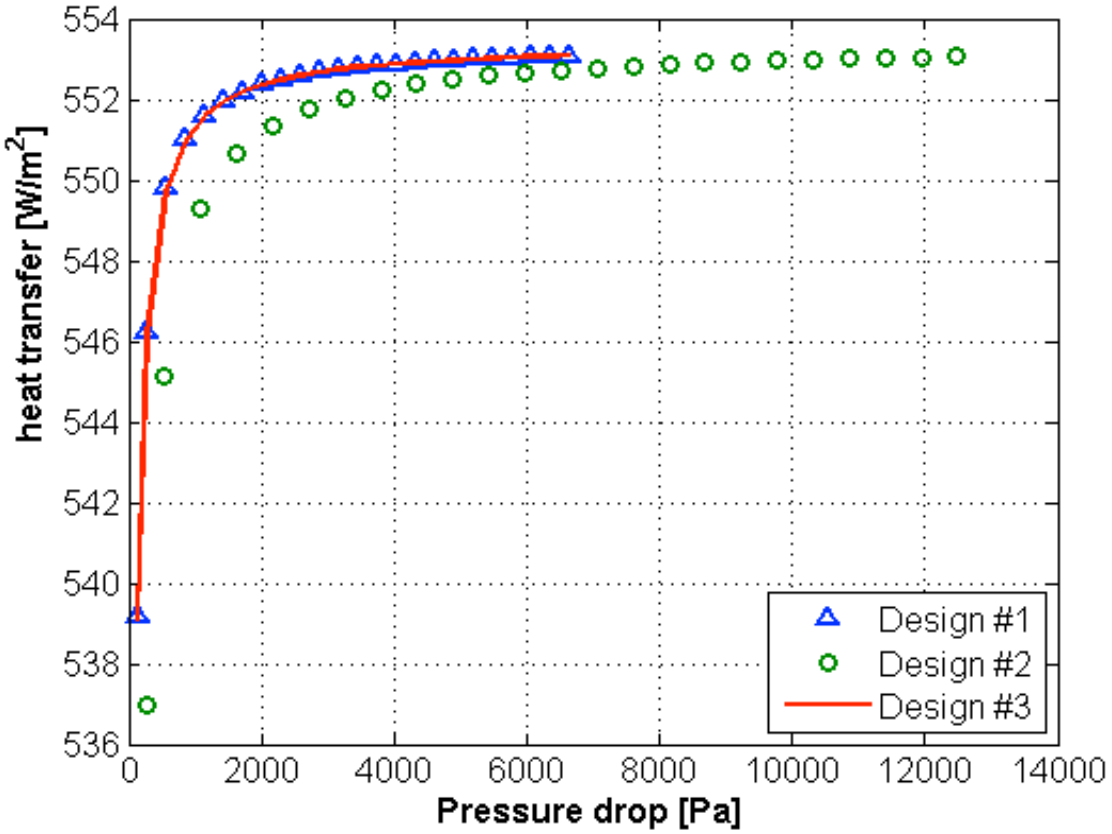
Copper Extrusion

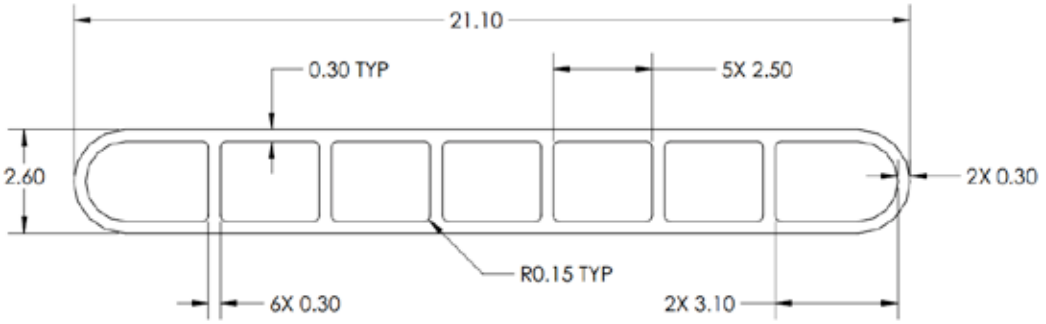




Copper minichannel tubes manufactured by Prof. Kraft, at Ohio University

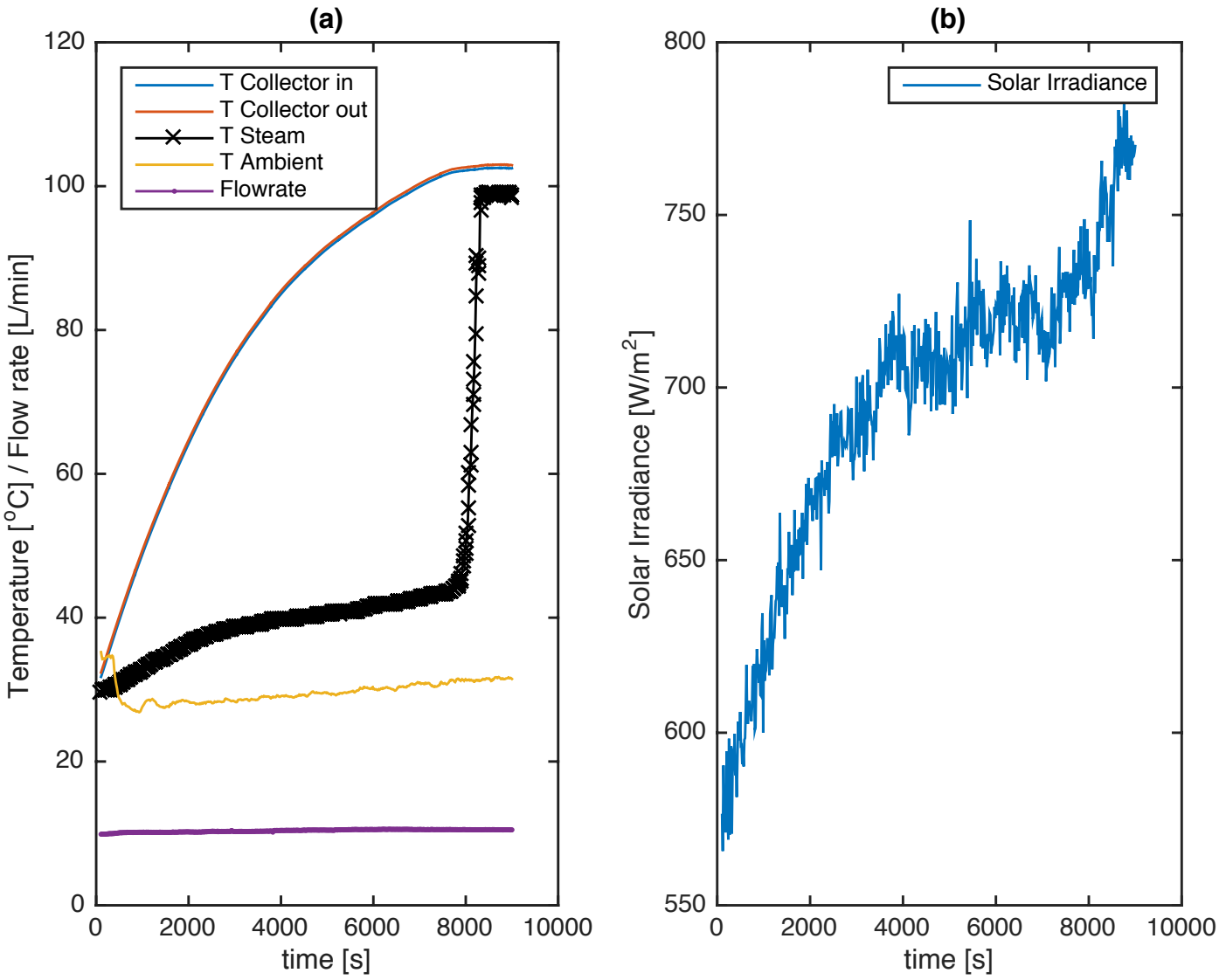
Performance Optimization





Collector Manufacturing

Low-Grade Steam Generation



Changes in Incentives

CPUC approved Advice No. 4953 (April 29, 2016)

SoCalGas:

Step 1 incentive level of $70/therm for Single Family

$25/therm for Commercial/Multifamily applications.

Natural Gas-Displacing Single-Family System Incentive Steps

Step	Incentive per annual therm displaced ()For SoCalGas only	Maximum Incentive Single-Family Residential Projects ()For SoCalGas only	Budget Allocation (in millions)
1	$29.85 ($70.00)	$4,366 ($10,238)	$7,907,636
2	$25.37	$3,710	$4,900,000
3	$14.30 ($0)	$2,091	$784,000
4	$3.23 ($0)	$472	$1,323,000

California Solar Initiative Thermal Program Handbook Rev 18.2.0

Acknowledgements